C02-19 Radiation Induced Failure Mechanisms and Preventive Shielding of Electronic Parts

Project Champion(s): NASA, TRW, DERA, EADS, UK MoD, NSWC
CALCE Team: D. Das, Prof. A. Tokuhiro (University of Missouri - Rolla), Prof. M. Bertino (University of Missouri - Rolla), and Prof. M. Pecht

Objective:

- To assess preventative polymer shielding techniques through testing and analysis on a promising shielding materials.
- To develop a web resource on effects of radiation on commercial electronic parts that are not radiation hardened.

Background:

In order to evaluate the performance of computers and electronic devices used in environments with ionizing radiation, there is a need to discern and assess the influence of damaging radiation on electronic parts. In the early years of electronic product developments, the high altitude and space use of electronic parts were areas of main concerns regarding radiation induced failure mechanisms. Most experimental and theoretical exercise in radiation effects on electronic parts is done by the military and aerospace community.

Many non-military missions such as those encountered in environmental remediation and nuclear safeguard activities have high radiation risk. There is a need to certify the reliability of components as they find applications in hazardous environments. In many commercial high-speed applications such as personal and business computing, the radiation concern comes from the lack of time to implement error correction algorithms in case of soft errors due to radiation from environmental sources. For these applications, there is need for theoretical and experimental assessment.

Radiation is also being used as an accelerating mechanism of electrical stress over time for failure mechanisms affected by high-energy carriers in the devices. There is also evidence of cumulative effects from different kinds of radiation that can only be detected through electrical characterization of the parts. These indicate a need for performing radiation exposure coupled with electrical testing.

Finally, preventative techniques that can be applied and maintained by part users as opposed to part manufacturers need to be concurrently investigated. Hanford Nuclear Services developed a polymer, which will be used as a shielding agent for radioactive waste storage containers. The material composite has 94.0% uranium oxide and 6.0 % polymer. These composites have high (6000 psi) mechanical strength and provide excellent shielding (>99.9%) for gamma and neutrons. The polymer can be sprayed on plastic surfaces to form thin uniform coatings. This project, in partnership with the manufacturer of the shielding material, will undertake a proof-of-concept study on the applicability of this HDE/polymer as a shielding material for susceptible electronic devices. Investigation of this polymer in shielding of electronic parts will be the first of its kind.

Approach:

In collaboration with the University of Missouri-Rolla's Reactor (UMRR), we propose initiating a project whereby components are systematically irradiated by neutrons or γ-rays in experimental ports available at the reactor. Even at a lower flux of 10^6 neutrons/cm^2/sec, thermal neutrons affect components with a critical charge below approximately 0.2pC. We are thus well suited to study SEE/SEU in components such as NAND gates and dividers, whose threshold for SEU is on the order of 0.1pC. In the pre- and post-irradiation phases, the parts would be subjected to test/diagnostic methods developed and used at CALCE. The electrical testing may be performed by outside electrical test laboratories. A realistic irradiation condition for the components would be developed through collaboration between UMRR and CALCE. In addition, the applicability of the HDE/polymer and boron-based coatings as potential shield materials, will be investigated as a practical means of prevention.

The functionality of post-irradiation components can be approached through a number of levels. One practical though "lumped" approach is to test the component in its intended application either by diagnostic (hardware-based) and/or by software means. This will just reveal the functionality of the component as a function of the irradiated condition but does not provide any information on the failure/degradation mechanism. The other approach used will be more "isolated test" whereby clarifying the failure mechanism in a simple device would be the main objective. The deduced failure mechanism would then be extrapolated to more complex, but inherently semiconductor-based components or tested in incrementally more complex components.

Deliverables:

- A feasibility case study report for the polymeric coating material as a radiation shield.
- The test report that will include the complete test plans including the rationale for them, the test and analysis results on the electrical parameter degradation due to radiation.
- A web tutorial that will include the failure mechanisms, available failure models, test standards, and effects of the newer technological developments on susceptibility to the radiation induced failure mechanisms. The report will have the latest literature survey on this topic and abstracts of the referred papers and standards will be made available.

Schedule:

Tasks	Oct-Dec	Jan-Mar	Apr-June	July-Sept	Oct
Generating a test plan in consultation with the industrial champions					
Selection of test parts through consultation of NASA databases					
Prepare test samples					
Perform radiation exposure tests					
Perform electrical tests before and after radiation exposure					
Web site development					
Develop conclusions and recommendations					
Report and review					